OPTICAL VIDEO LINK ON MULTIMODE GLASS FIBER

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Dedicated to my ever loving family for their support and encouragement at all time.

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ABSTRACT

Recently fiber optic has found its greatest application in voice, data and video transmission. Video signals encode continually changing pictures and sound, which mean that it requires more capacity. Fiber optic edge out conventional copper wire in this case as fiber has information capacity thousands of times greater. Therefore the purpose of Optical Video Link on Multimode Glass Fiber is to transmit broadband video over moderate distance with a low cost and minimal complexity. It is a simplex communication from point to point with multimode glass fiber as its transmission medium and utilizing frequency modulation (FM).

Chapter 1 gives a brief idea of the project and its objectives. Chapter 2 provides the fundamental concept of fiber optic system. Chapter 3 explains the system design of the project, which includes the information source and the modulation used in the design. Chapter 4 discussed the implementation and testing of the project, which displays some results from the testing. Finally, Chapter 5 gives the conclusion for the project and provides some recommendations to improve the design.

ABSTRAK

Aplikasi gentian optik dalam penghantaran suara, data dan video sering digunakan pada masa kini. Isyarat video mengkodkan pertukaran gambar dan suara secara berterusan dan oleh itu, ia memerlukan kapasiti yang lebih besar. Gentian optik digunakan secara lebih meluas berbanding dengan wayar tembaga kerana ia mempunyai kapasiti yang jauh lebih besar. Oleh itu, tujuan Optical Video Link on Multimode Glass Fiber adalah untuk menghantar isyarat video "broadband" pada jarak yang sederhana, kos yang rendah dan lebih ringkas. Ia merupakan sistem komunikasi searah dari satu titik ke titik yang lain melalui "multimode glass fiber" sebagai media penghantaran dan mengaplikasikan modulasi frekuensi (FM).

Bab 1 memberi satu idea mengenai projek ini secara ringkas. Di samping itu, objektif projek juga diterangkan dalam bab ini. Dalam Bab 2 pula, konsep asas sistem gentian optik diterangkan. Keterangan mengenai rekabentuk sistem termasuk sumber informasi dan modulasi yang digunakan terkandung dalam Bab 3. Bab 4 membincangkan pelaksanaan ujian yang dijalankan dalam projek ini di samping menunjukkan beberapa hasil ujian yang telah dijalankan. Akhirnya, Bab 5 memberi kesimpulan daripada projek ini dan beberapa cadangan telah diberi untuk memperbaiki rekabetuk projek ini.

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INTRODUCTION

1.1 Overview of Video Over Fiber

Video signals encode continually changing pictures and sound (note: the design of this project only transmits picture information without audio). The picture is actually made up of many horizontal lines drawn one after another. The video signal contains the information to draw these lines, detailing whether parts of the line should be dark or light and how the colours should be displayed. They are transmitted in standard formats and require considerably more capacity than voice or digital data. Compare to metal cable, fiber offers benefits of lighter weight, larger bandwidth, smaller size, longer transmission distance, immunity to electromagnetic interference, and avoidance of ground loops and potential differences.

1.2 Project Overview

In this project, a circuit was designed to process the input data, which is the composite video signal before it is transmitted through multimode glass fiber. The design was only for the transmitter part. The information source i.e.

composite video signal was frequency modulated and transmitted on an 820nm wavelength. The design operates in analog system.

1.3 Objective of the Project

Several key objectives for conducting this project that would like to be achieved are:

- To gain much knowledge on fiber optic technology as the technology is growing rapidly especially in Malaysia. It would play a significant role in the field of telecommunications.

- To improve knowledge on circuit designing and implementation of the circuit. The process of designing would need good knowledge on electronics.

- To have hand-on knowledge of transferring design from paper to functional device with the help of proper tools.

- To learn project management. This is essential experience to learn on how to manage a project with certain limit of time and cost.

- To implement the design of an optical video transmitter.

1.4 Chapters Outline of this Thesis

Chapter 1 gives a brief idea of the project. It also describes the objective of the project besides providing the overview for video over fiber.

Chapter 2 provides the fundamental concept of fiber optic system. It includes the advantages and disadvantages of fiber optic, its basic theory of operation, attenuation in fiber optic systems, light source and light detector.

Chapter 3 explains the system design of the project, which includes the information source and the modulation used in the design.

Chapter 4 discussed the implementation and testing of the project, which displays some results from the testing.

Chapter 5 gives the conclusion for the project and provides some recommendations to improve the design.

CHAPTER 2

FUNDAMENTAL OF FIBER OPTIC

2.1 Introduction to Fiber Optic

Communication systems that use light as the carrier of information have recently received a great deal of attention lately. Optical communication is a radical departure from the conventional electronics communication. Instead of the signal being carried by electrons moving back and forth over metallic wires, lightwaves are being guided by tiny fiber of glass or plastic to accomplish the same purpose.

Over the years, fiber optics has been developed in a series of generations that can be closely tied to wavelength. The earliest fiber optic systems were developed at an operating wavelength of about 850 nm. This wavelength corresponds to the so-called "first window" in a silica-based optical fiber. The window is a wavelength region that has approximately 3 dB / km loss. Then came the "second window" at 1300 nm with a lower attenuation of below 1 dB / km. Later, the "third window" at 1550 nm, was developed. It offered the theoretical minimum optical loss for silica-based fibers, about 0.2 dB / km. Figure 2.1 show the three wavelength regions of optical fiber.

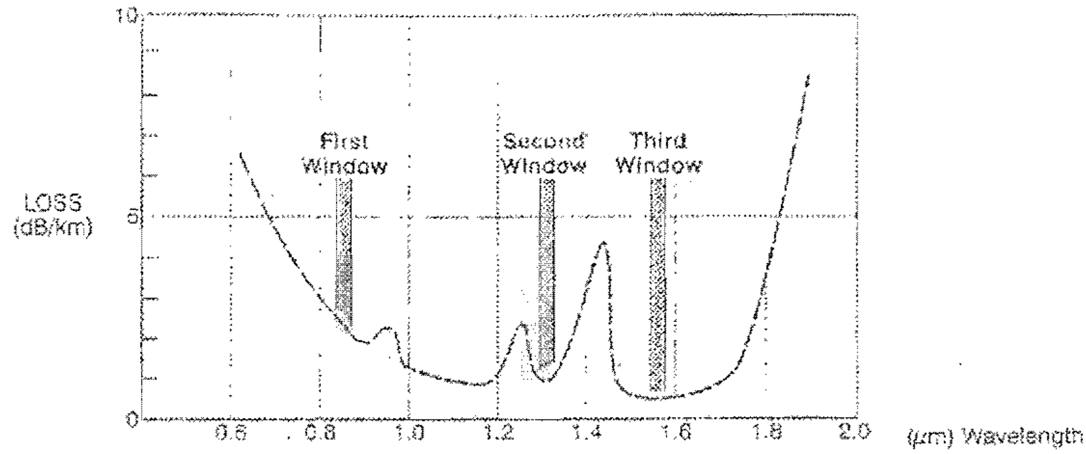

Figure 2.1 Three Wavelength Regions of Optical Fiber. [2]

2.2 Advantages and Disadvantages of Fiber

Fiber is used in a particular application because it exhibits some advantages over other alternative technology such as coax and twisted pair. Some of the primary advantages of fiber over other terrestrial communication medium are:

i) *Large length-bandwidth capability.* Because of its wide bandwidth, theoretically in excess of 10 GHz and attenuation less than 0.3 dB for a kilometer of fiber, it is often the lowest-cost transmission medium per channel kilometer [3]. Figure 2.2 compares the transmission properties of fiber with those of other conventional transmission media. The attenuation of copper wire has a strong and direct dependency of frequency. The dependency in fiber is less a function of signal frequency except where it approaches longer transmission distance.

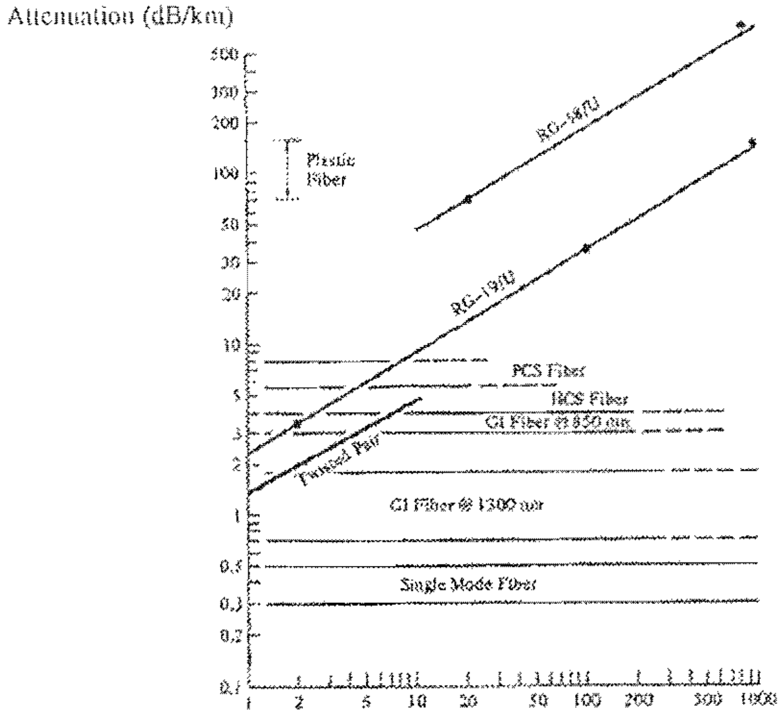

Figure 2.2 Comparison of Fiber Performance with Coax and Twisted Pair. [4]

ii) *Smaller diameter, lighter weight cables.* These cables offer obvious advantages with the thin-hair optical fiber. The size reduction makes fiber optic cables the ideal transmission system for ships, aircraft and high rise buildings, where space is a premium. Reduction of size leads to reduction in weight. The weight advantages is particularly useful in such application as aircraft, where weight is key to fuel consumption and cargo capacity.

iii) *Interference immunity.* Fiber is a dielectric waveguides. It therefore is not affected by, nor does it radiate, electromagnetic energy. It is immune to crosstalk from adjacent fibers and does not conduct ground currents that can effect the signal.

iv) *Immunity to inductive interference.* As dielectric, rather than metal, optical fibers do not act as antennas to pick up radio frequency, electromagnetic interference (EMI) or electromagnetic pulse (EMP). Electrical disturbances such as lightning, nearby electric motors and relays could be ignore because fiber optic cables are carrying light rather than electrical signal. The result is noise free transmission.

v) *High quality transmission.* As a result of noise immunity of the fiber transmission path, fiber routinely provides communications quality orders of magnitudes better than copper microwave. The general standard for a fiber transmission link is 10^{-9} BER minimum with 10^{-11} or better as the norm.

vi) *Low installation and operating cost.* The wide bandwidth and low loss decreases the number of repeaters needed, therefore the cost of capital in the outside plant. The reduction of repeaters reduces the maintenance, power and operating expenses. The simplicity, low power requirements and very high reliability of the terminal equipment also reduces the maintenance costs.

vii) *Secure transmission and tempest.* Because fiber does not radiate a field of electromagnetic energy, it is inherently secure unless physically contacted or distorted. The fiber and terminating equipment can be designed to detect loss of energy or resultant perturbation in the modal patterns and initiate an alarm.

However, fiber too has its disadvantages such as:

i) *Radiation hardness.* Fiber darkens to some degree when bombarded by high-energy nuclear particles. If the event is a nuclear blast, the fiber first glows during the initial event, then darkens very rapidly to the point it loses useful transmission properties.

ii) *Nonconductor.* Fiber cannot transmit electrical power. This limits its application where the receiving terminals such as telephone set, must be powered from the line. For such applications the cable must provide separate conductors for power.

iii) *Hydrogen absorption.* Molecular hydrogen can diffuse into silica fibers and produce attenuation change. Hydrogen can come from certain cable and fiber buffering materials. Since it is confined within the cable, the hydrogen can build up to significant concentration.

iv) *High cost in low bandwidth applications.* Generally fiber is more cost effective if its capabilities such as high bandwidth and low attenuation are required. As for the low bandwidth and shirt distance applications, fiber cost more than copper.

2.3 Total Internal Reflection

The working of optical fibers is based on the principles of *total internal reflection*. Light is bent as it passes through a surface where the refractive index changes, for example, as it passes from air into glass. Refractive index is the ratio of the speed of light in a vacuum to the speed of light in the medium. Figure 2.3 (a) shows that, refraction occurs when a ray of light is incident on the interface between two dielectrics of different refractive indices. The angles of incidence ϕ_1 and refraction ϕ_2 are related to each other and to the refractive indices of the dielectrics by Snell's law of refraction, which is written

$$n_1 \sin \phi_1 = n_2 \sin \phi_2 \qquad \text{Eq. (2.1)}$$

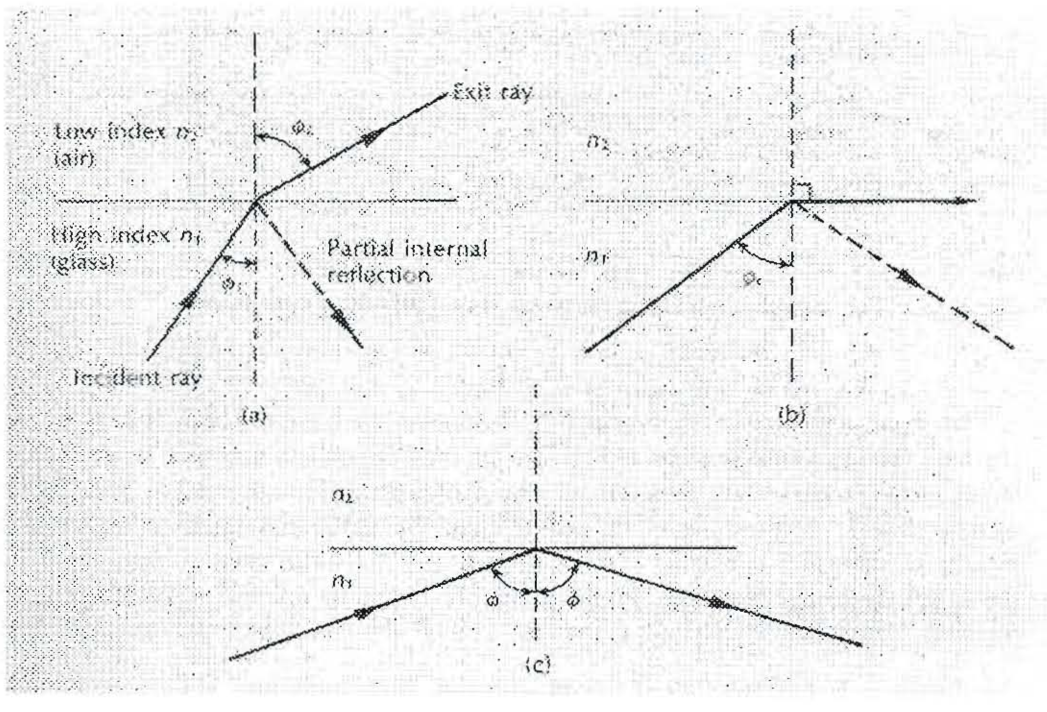

Figure 2.3 Light Rays Incident on High to Low Refractive Index Interface. [1]